

Hopewell Archeology:

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4. Geophysical Investigations of the Hopewell Earthworks (33RO27), Ross County, Ohio

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Abstract

The Hopewell site in southern Ohio is one of the most important and famous prehistoric sites in North America. Built about AD 100, it consists of more than 3 miles of earthworks and over 40 mounds. The earthworks of the Ohio Hopewell suggest a substantial investment of human labor and cultural organization that is still poorly understood after more than 150 years of study. Geophysical survey techniques can provide the means to study these earthworks in a rapid and nondestructive manner. For the past 200 years, these earthworks have been subject to the degradation of agriculture. A study comparing multiple geophysical survey techniques on the Mound 23 area of the Hopewell site was conducted in 2004. The results of magnetic, resistance and conductivity surveys were compared.

Introduction

Throughout the Ohio River valley, during the period between 200 BC and AD 400, inhabitants of this region built hundreds of earthen mounds and dozens of earthen enclosures. Most of the mounds appear to be associated with mortuary activities, and often contain elaborate and artistic objects made from a wide range of exotic raw materials. The earthen enclosures are typically geometric in form, and range in size from a few acres to more than one hundred acres. Archeologists have named the archeological record associated with these mounds and earthworks the Hopewell Culture, after a site located about 6 miles northwest of Chillicothe, Ohio.

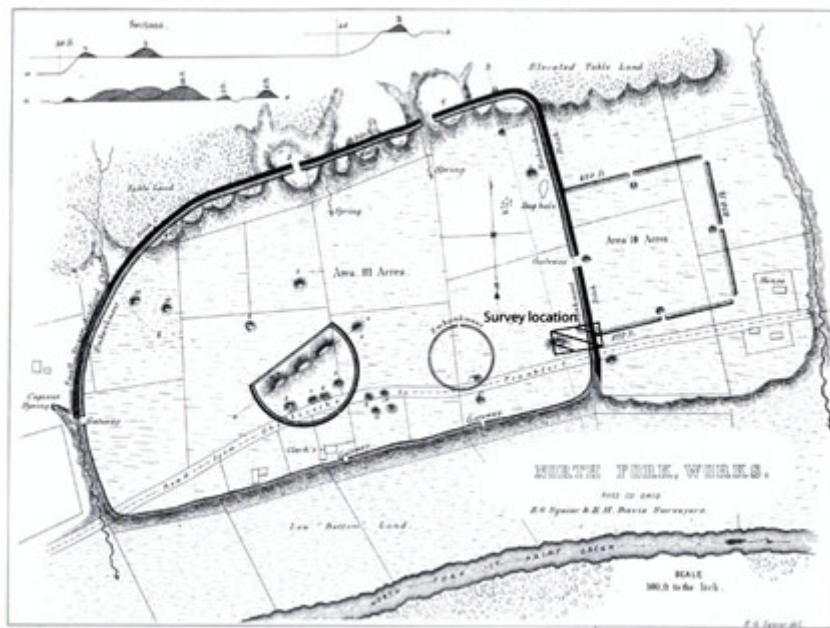


Figure 1. 1846 map of the Hopewell Earthworks (Squier and Davis, 1848).

Site Background

The Hopewell mound group was first documented in 1820 by Caleb Atwater. At that time, the land was owned by W. C. Clark, so the site was named Clark's Fort. Since that time there have been only three major investigations into the archeological remains of the site. These major investigations focused primarily on the burial mounds associated with the earthworks. The site was first excavated by Ephraim G. Squire and Edwin H. Davis in 1845. During their investigation, they estimated that the embankments cover over three miles in length and the earthworks contain three million cubic feet of placed earth (Squire and Davis, 1847). A structure of this size suggests a substantial investment of human labor and social organization. This is truly remarkable considering the land surrounding the Scioto river valley is littered with dozens of these earthworks.

The next excavation was led by Warren K. Moorehead in 1891. At that time, Moorehead renamed the site after the landowner, M. C. Hopewell. His work, too, focused almost exclusively on the burial mounds. Among the mounds he excavated, one of the largest included mound 23, which was surveyed during this project. More than 50 burials were found within the mound and hundreds of exotic burial goods were recovered. At the base of the mound, Moorehead (1922) noted a floor of varied sized gravels.

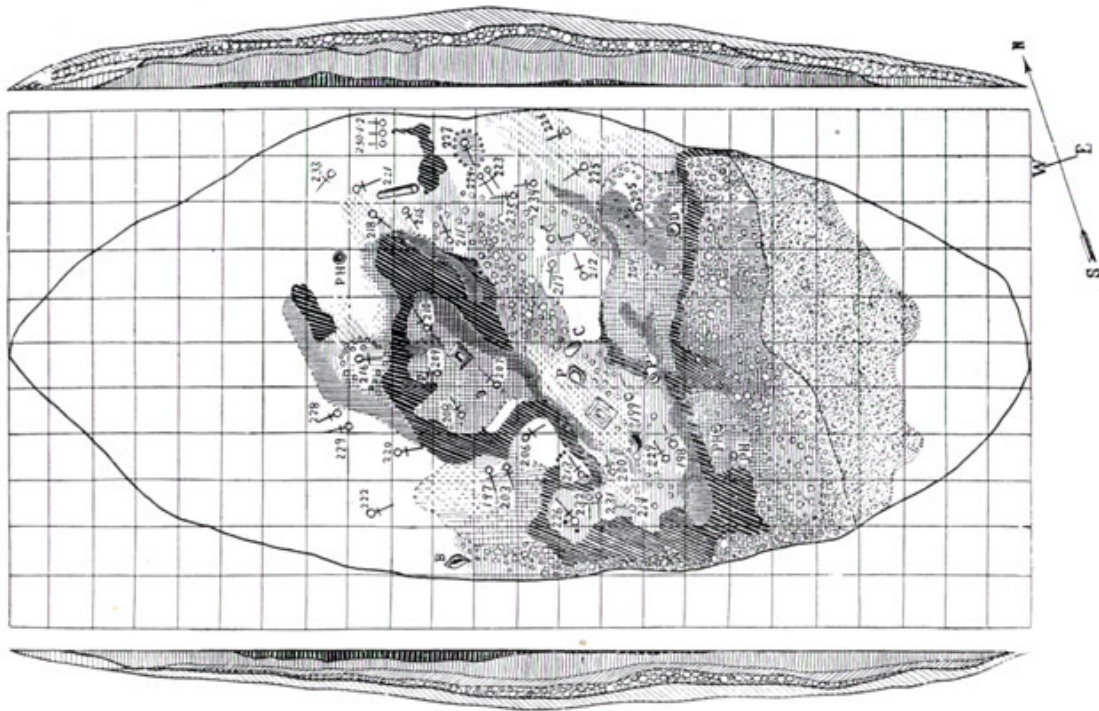


Figure 2. 1891 plan-view map of mound 23 (Moorehead, 1922).

It is important to note the method Moorehead's team employed for excavation. Moorehead's team used horse drawn scrapers to reduce the mound to about four feet above the modern surface. The team then hand excavated the remainder. The team excavated a trench to the base floor of the cultural remains and placed the backfill behind them. They then stripped mostly vertical layers from the wall of the trench, thus moving their excavation perpendicular to the minor axis of the mound. This excavation strategy that means that, excepting artifacts, nearly all of the original

materials of the interior portion of the mound are still more or less in situ. The soil may be moved, but it was moved uniformly and only by a distance of ten feet or so.

In 1922 the last major excavation of the Hopewell site was conducted by Henry C. Shetrone. The excavation was conducted to reexamine all of the previously excavated mounds (Greber and Ruhl 1989, Shetrone 2004). Shetrone found that the western third of the mound had not been adequately examined. Again, Shetrone found the gravel base floor and noted that it contained a great degree of burned soils.

Geophysical Survey Methods in Archeology

Geophysical surveys in archeology can be a very useful tool to guide excavations and to examine variation in subsurface features and soils over large areas. The use of geophysical survey techniques can supply an excavation with a “road map” to subsurface features without disturbing the site. There are many different types of surveys, each with its own sensitivities and drawbacks. As Weymouth (1986) notes, there are two general types of geophysical methods: *active* and *passive*. The vast majority of methods employed for archeological purposes fall under the active category. The active survey methods used for this research include electromagnetic conductivity and electric resistance. In each of these methods, a signal is sent from the measuring instrument into the ground. Depending upon the electrical properties of the soils, the signal will then be altered from its original state and sent back to the instrument to be measured.

Resistivity. Of all the geophysical methods currently utilized for archeological purposes, resistivity surveys were the first to gain popularity. This method sends an electric current into the soil via two conducting probes placed a few centimeters in the ground. Two other probes measure the voltage that is transferred through the ground. The ratio of the voltage to the current that is applied yields the resistance according to Ohm’s Law ($R=V/I$ where R =resistance, V =volts, and I =current). The principal factor that determines soil resistance is its water content and distribution (Weymouth, 1986; Clark, 1990). When the ground is completely saturated, soil resistance will be at a minimum because water is a good conductor of electricity. Conversely, when the ground is completely devoid of moisture, electrical resistance will be at a maximum. Optimally, a survey would be conducted when the ground is moderately saturated. In this case, the water distribution between soil horizons, and buried cultural remains, would be uneven. For example, the soil in a buried ditch or pit tends to be less dense than the surrounding earth. This would allow for a greater accumulation of moisture within the fill than in the surrounding area. Hence, the ditch would appear as a low resistance area compared to the surrounding soils.

The depth the current will travel through the soil depends on the spacing of the probes and the physical characteristics of the soil itself. In a uniform matrix, the voltage will travel in regular hemispheres between the current probes. Generally, the depth of penetration will equal the horizontal spacing of the current probes (Clark, 1990; Kvamme, 2001). This survey used the Geoscan Research RM-15 parallel twin configuration and a 0.5-meter probe separation. This allowed for roughly a 0.5-meter maximum penetration.

Conductivity. Conductivity is the theoretical inverse of resistivity. However, because of the way in which a conductivity meter senses information, it can yield differing results. Conductivity meters employ non-contact transmitting and receiving coils. An electromagnetic signal is sent out by the transmitter and induces a current in the soil. This current creates a secondary magnetic field which is then sensed and measured by the receiving coil. Introducing a new magnetic field in the soil makes this method sensitive to metals which will appear as extreme values. This survey, however, still retains sensitivity to the same types of features as a resistance method. The Geonics EM-38 was used for the conductivity portion of this survey. This instrument operates on a frequency of 14.6 kHz and houses a 1 m coil separation, it is capable of delivering four measurements per second. The EM-38 also has two settings for depth. The vertical dipole mode, which measures a depth up to 1.5 m, was used in this survey.

Magnetic. Magnetometry was the only passive geophysical method employed in this study. This method measures the relative strength of the earth's magnetic field. The magnetic properties of a soil depend on the concentration of iron compounds like hematite, magnetite, and maghaemite (Weymouth 1986). Undisturbed earth will yield a uniform magnetic field, whereas buried ditches, etc., will tend to be more or less magnetic than the surrounding matrix. Magnetometers are generally most sensitive to metals and fired materials. Metals will appear in magnetic data as paired strong positive and negative values which is referred to as a dipole. When a material is heated to a certain point the heat will "reset" the material's magnetic clock. This process is called *thermoremanent magnetism* (Weymouth 1986). The atoms of the substance will align themselves to magnetic north at the time of cooling. For this reason burned features, such as hearths, kilns, fired bricks, and burned house floors, are readily visible in magnetic data. Typically, most anomalies will range between ± 5 nanotesla (nT). It is not uncommon, however, for a feature to fall within .1 nT of the background magnetic strength.

The Geometrics G-858 cesium gradiometer was used for the magnetic portion of the survey. The sensors were mounted on a vertical shaft at a 1-meter probe separation with the lower sensor measuring the magnetic field of the soils. The upper sensor measures the background magnetic field. The bottom reading was then subtracted from the top to cancel out the magnetic variance not related to soil conditions.

Survey area

The survey area was a rectangular block 60 meters north-south and 120 meters east-west. The western portion of the block was positioned to cover roughly two-thirds of mound 23. The eastern half of the block covered the east wall and associated ditch of the large enclosure. Additionally, the eastern portion of the block was thought to cover the approximate location of the south wall of the small square enclosure.

At the time of Moorehead's excavation in 1891, mound 23 stood 3-4 meters high and was roughly 46 meters in its greatest diameter. Since that time, the site has been seriously degraded from agriculture. At the time of the survey, mound 23 and the large earth wall stood no more than one meter above the normal ground surface. Nothing could be seen of the earthen ditch or the wall of the small square.



Figure 3. 1891 photograph of mound 23 (Moorehead, 1922).

The survey area was situated to answer three main questions. First, what archeological remains, if any, were left in mound 23? Second, what can be detected within the earthen wall and ditch of the large enclosure? Finally, what is the preservation quality and exact location of the small square enclosure?



Figure 4. 2004 photograph of mound 23.

Survey and interpretation methods

The base lines of eighteen 20 by 20-meter grids were first laid out with a transit. Wooden stakes were then placed in the corners of each survey grid. One hundred meter tapes were then stretched between the east-west running baselines to place the remaining corner stakes. During the survey two 20-meter ropes were placed along the east-west lines of each grid to form a boundary. A third rope was moved along the ground at one meter intervals to serve as a guide. The guide ropes were marked with colored electrical tape every half meter and flagging tape every 5 meters. At the end of data collection, the instruments were then downloaded into a portable laptop computer for processing. Data manipulation was carried out using Geoplot, Surfer 7, and ArcGIS 8. For final presentation, the data was transferred into Surfer7. The grids were set up in Surfer using the Krigging method.

The interpretation process was designed to answer the survey design goals stated previously. Additionally, the survey was intended to provide a means to compare multiple data sets. The goal was to produce an easily interpretable map of the differing data sets that would clearly show the anomalous areas of each survey. To this end, the conductivity and resistance data were filtered and smoothed using Geoplot. The datasets were then exported into Surfer 7 for interpretation. Two differing contour plots were created to highlight the anomalies of each data set. The first contour plot depicted the typical value range of the anomalies present. The second plot reflected a range of standard deviations from the mean of the data set. The contour plots were then exported to ArcGIS 8.3. Each of the three contours were assigned a different color and displayed

in partially transparent fashion. The resulting image served as the finished product of this attempt at correlation.

Results

Resistance. Resistance data was collected at one meter traverses with a half-meter sampling interval. A total of 14,400 readings were collected for the survey area. The data ranged in values from 27.2 to 95.0 Ohms. The mean of the data was 44.4 Ohms with a standard deviation of 5.75 Ohms.

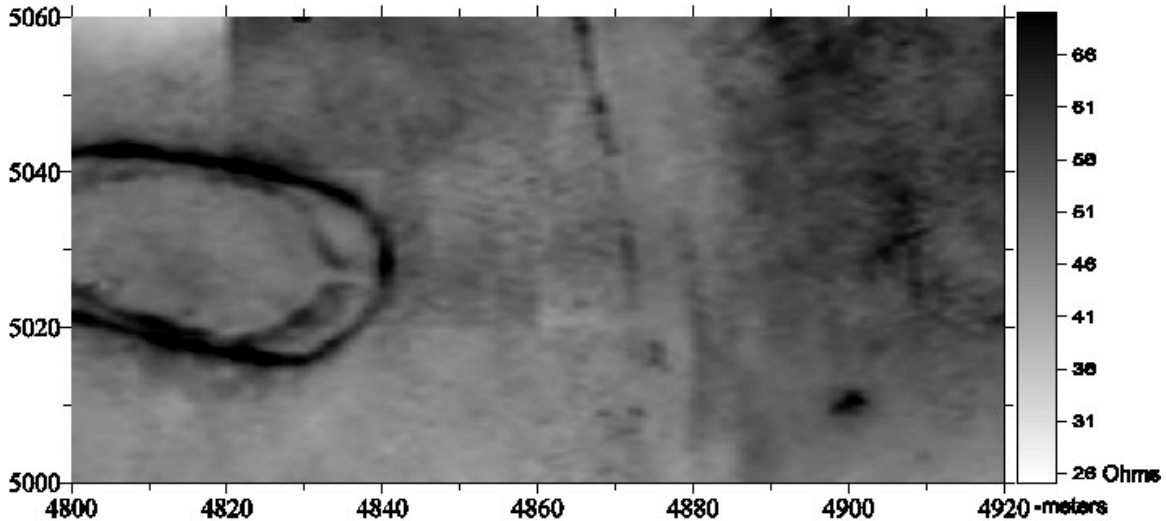


Figure 5. Resistance Data.

Mound 23 is displayed clearly in the resistance data. The highest values in the data set mark the limits of the mound. This ring is probably the result of large gravels that were placed during the construction of the mound. The resistance data also revealed weaker anomalies in the interior portion of the mound. The anomalies probably result from gravels that were associated with the floor of the mound structures.

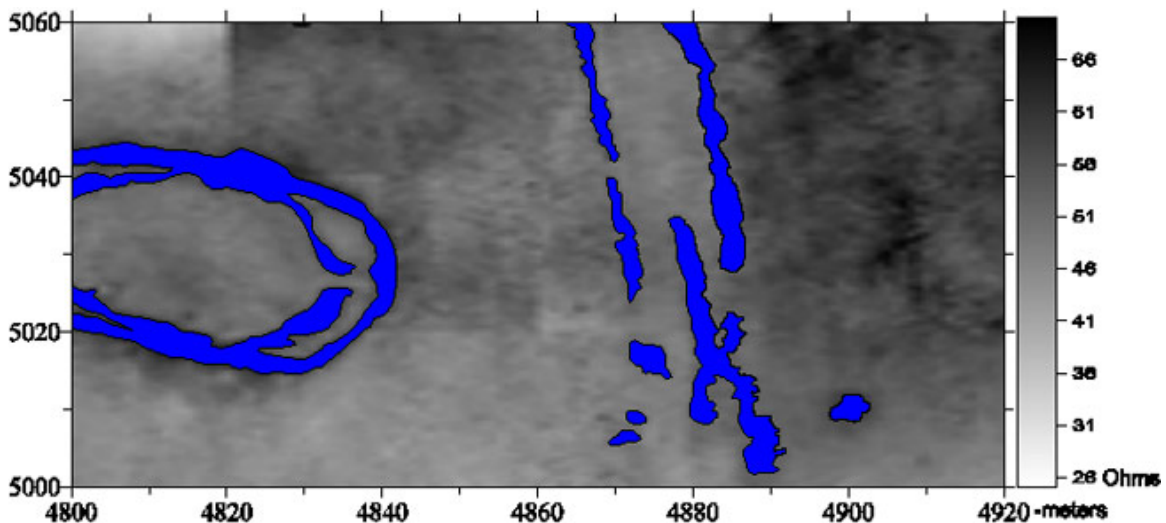


Figure 6. Anomalous areas of the resistance data.

The large earth wall to the east of the mound is displayed as a linear anomaly that runs slightly northwest to southeast. This linear anomaly could also be the result of gravels that were placed

during the construction of the earthwork. Near the data point E4885 N5060, there is a boundary that follows the same direction. This boundary separates a zone of high resistance in the east from the lower resistance of the rest of the map. This boundary marks the edge of the earth wall.

Conductivity. Conductivity data was collected at one meter traverses with a quarter-meter sampling interval. A total of 28,800 readings were collected for the survey area. The data ranged in values from -4.70 to 11.39 milisemens per meter (mS/m). The mean of the data was 6.26 mS/m with a standard deviation of 1.64 mS/m.

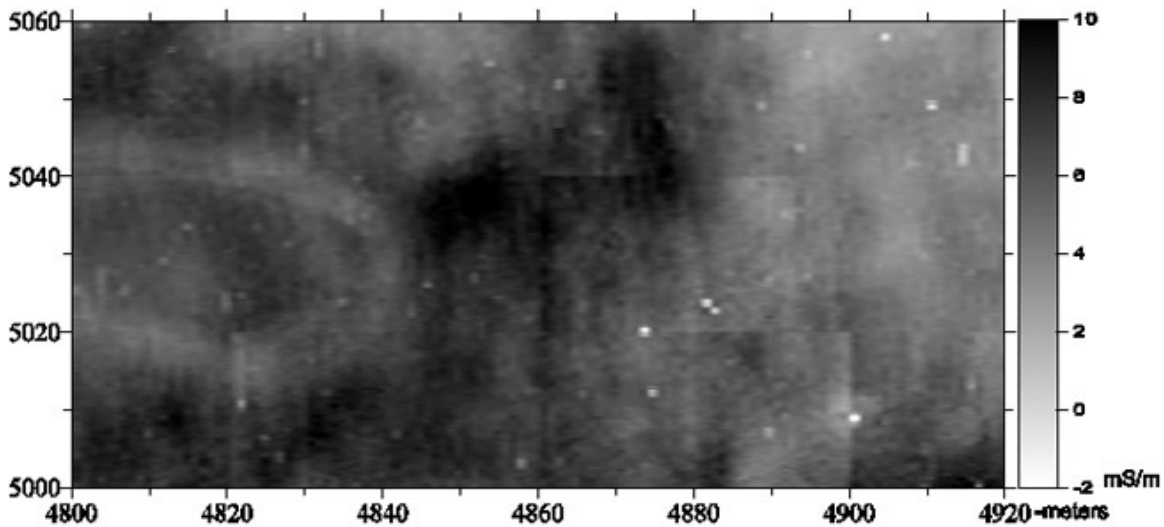


Figure 7. Conductivity Data.

As expected, the conductivity data showed the near inverse of the resistance data. The exception was that the anomalies were not nearly as strong. The anomalies associated with mound 23 appeared as a light halo compared to the background area. Curiously, these values fell within one standard deviation from the mean. This could have been due to the general poor overall conductivity of the soil.

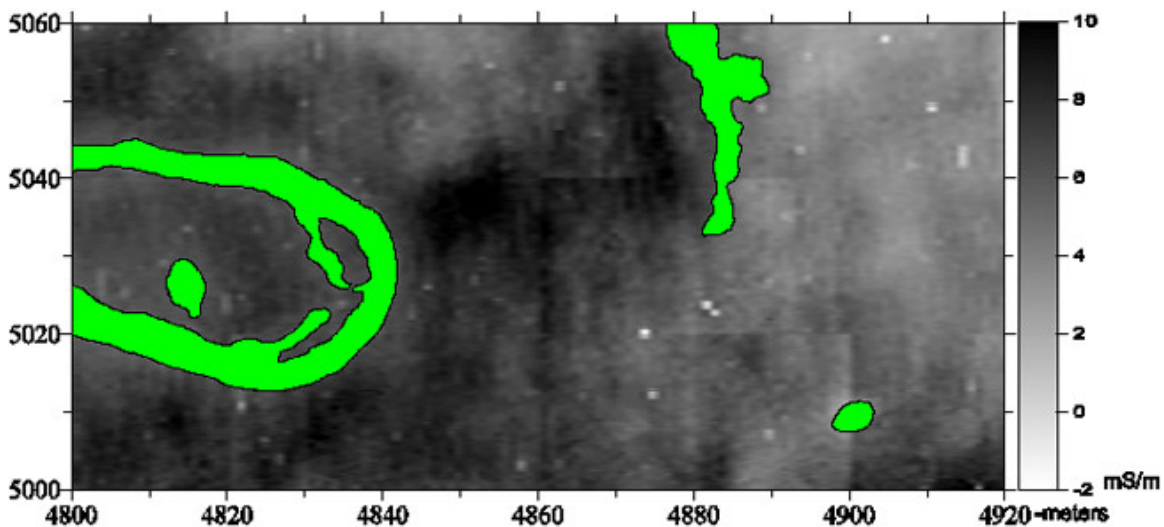


Figure 8. Anomalous areas of the conductivity data.

The same boundary associated with the eastern edge of the large enclosure is also present in the conductivity data. Here, the boundary is marked by values of high conductivity to the west and

low values to the east. The values associated with this boundary fall within the same range as the anomalies of the mound.

Magnetic. Magnetic data was collected at one meter traverses. The instrument was set to take readings every 0.2 seconds which allowed for roughly 5 samples per meter to be taken. A total of 36,918 readings were collected for the survey area. The background magnetic field strength averaged at 53,334.58 nT. The vertical gradient ranged in values from -25.5 to 69.4 nanotesla per meter (nT/m). The mean of the data was 1.91 nT/m with a standard deviation of 3.21 nT/m.

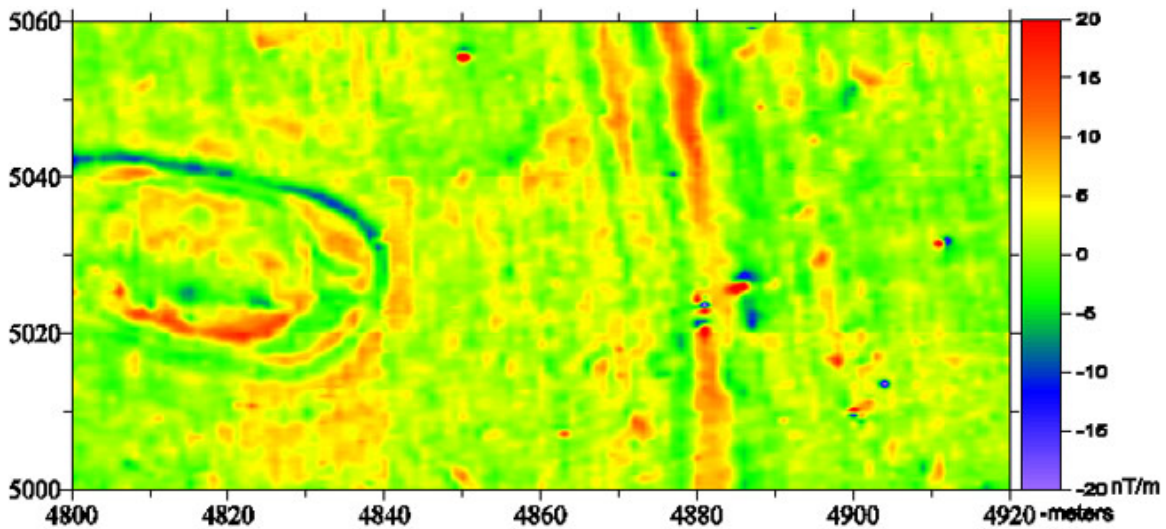


Figure 9. Magnetic Data.

The magnetometer clearly displayed the northern edge of the mound as a strong negative linear anomaly. The interior of the mound is displayed as strong positive values in the south and slightly lesser positive values in the north. These boundaries could mark the walls of burned structures where the walls burned longer or with more intense heat.

The large enclosure is marked by two parallel lines running through the length of the survey area. The east line is of much greater intensity. Additionally, there is a third line to the east which marks the eastern boundary of the ditch.

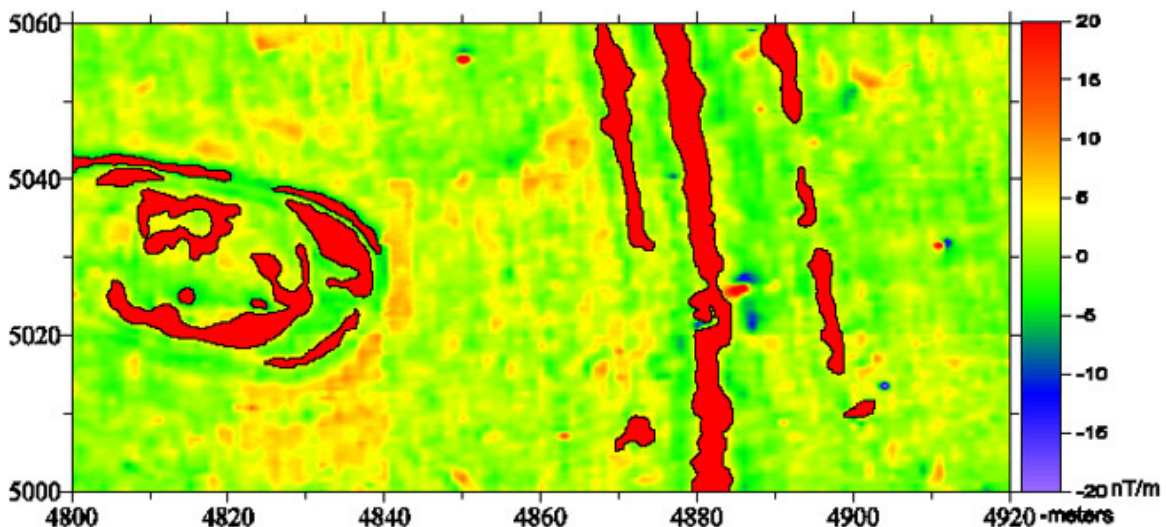


Figure 10. Anomalous areas of the magnetic data.

Overlay. The comparison of the three geophysical survey types proved to be quite informative. The plot of the anomalous areas of the surveys showed the exact relationship between the data sets. The anomalies associated with mound 23 showed a close approximation of the physical boundary of the mound. The conductivity and resistance data highlighted the margins of the mound while the magnetometer sensed the interior. The earth wall was displayed in a similar manner to the mound. The outer extremities were displayed by resistance and conductivity, while the magnetometer displayed the interior of the wall.

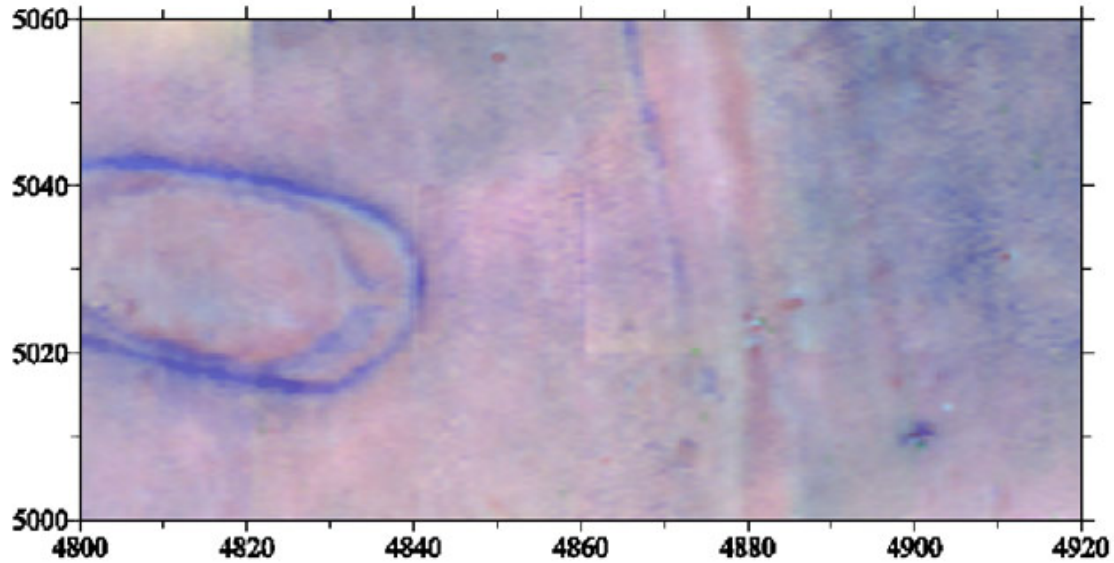


Figure 11. Image of the overlapped data sets. Resistance is displayed from blue to white, conductivity is displayed from white to blue, magnetic data is displayed from red to white.

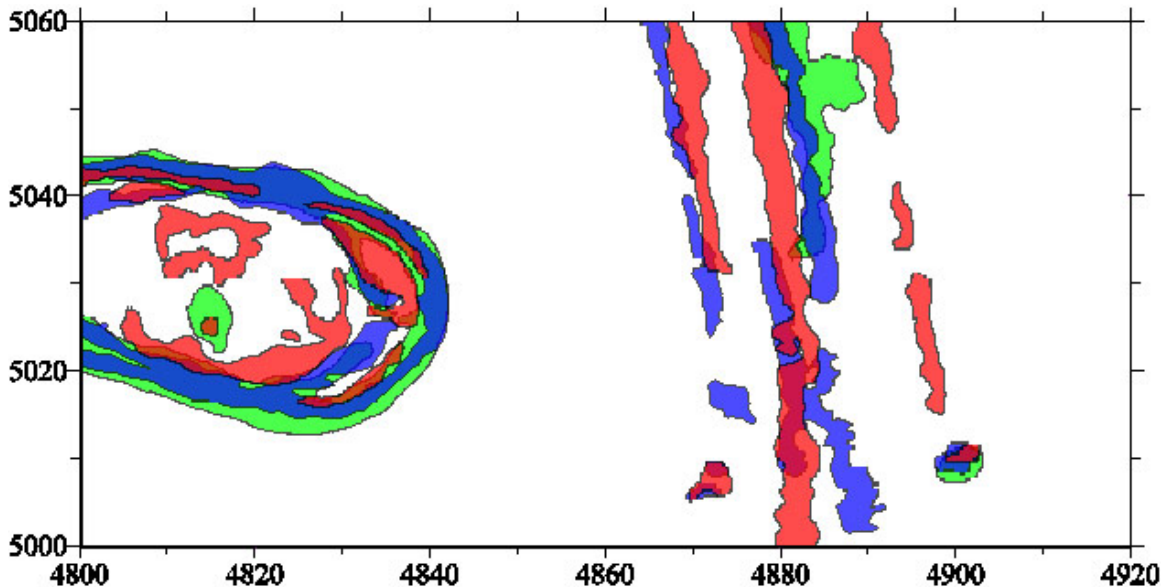


Figure 12. Image of the anomalous areas of the data sets overlapped. Resistance is displayed as blue, conductivity is displayed as green, magnetic data is displayed as red.

Conclusions

As archeological investigation techniques improve, it can often become quite useful to reexamine previous studies. Mound 23 in this survey had been previously excavated twice. Thus, it would be natural to assume that most, if not all, of the cultural remains were removed. However, this study proved that there may still be features of archeological significance left in the mound. Magnetic data pointed to burned surfaces associated with the floors of the pre-mound funeral structures. Based on this evidence, we can now see that the previous excavation strategies were not focused on recovering anything below the floor. Many of the mound's base features may still be intact.

The results from the magnetic data also suggested that the large enclosure is still present below the surface. Resistance and conductivity showed an area of higher conductivity/lower resistance to the east of the large wall. Magnetic data pointed to internal anomalies possibly resulting from ritual burning or a stone lining. The data clearly showed that although the earthworks may not be visible on the ground surface, much of the core of the wall still remains below surface.

Acknowledgments

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